Polybrominated Diphenyl Ethers in Maternal and Fetal Blood Samples

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Polybrominated diphenyl ethers (PBDEs) are widely used as flame retardants in consumer goods, such as plastics, electronics, textiles, and construction material. PBDEs have been found in human milk, fat, and blood samples. Rodent studies indicate that PBDEs may be detrimental to neurodevelopment, possibly by lowering thyroid hormone concentrations in blood. In the present study, we determined concentrations of PBDEs and thyroid hormones in human fetal and maternal serum. Patients presenting in labor to Indiana University and Wishard Memorial County hospitals in Indianapolis, who were older than 18 years, were recruited to participate. Twelve paired samples of maternal and cord blood were obtained and analyzed using gas chromatographic mass spectrometry; thyroid hormone concentrations were determined by radioimmunoassay. Six congeners of PBDE were measured in maternal and fetal serum samples. The concentrations of total PBDEs found in maternal sera ranged from 15 to 580 ng/g lipid, and the concentrations found in fetal samples ranged from 14 to 460 ng/g lipid. Individual fetal blood concentrations did not differ from the corresponding maternal concentrations, indicating that measurement of maternal PBDE blood levels is useful in predicting fetal exposure; similarly, other reports have shown a high correlation between PBDE in mother's milk and fetal exposure. In accord with reports on other biologic samples, the tetrabrominated PBDE congener BDE-47 accounted for 53–64% of total PBDEs in the serum. The concentrations of PBDEs found in maternal and fetal serum samples were 20–106-fold higher than the levels reported previously in a similar population of Swedish mothers and infants. In this small sample, there was no apparent correlation between serum PBDEs and thyroid hormone concentrations. Our study shows that human fetuses in the United States may be exposed to relatively high levels of PBDEs. Further investigation is required to determine if these levels are specific to central Indiana and to assess the toxic potential of these exposure levels. *Key words:* brominated diphenyl ethers, cord blood, human, pregnancy, serum. *Environ Health Perspect* 111:1249–1252 (2003). doi:10.1289/ehp.6146 available via *http://dx.doi.org/* [Online 10 March 2003]

Several substances are added to plastics, electronics, textiles, and construction material to protect against fire. Brominated flame retardants (BFRs) are the cheapest flame retardant and account for 39% of worldwide flame retardant production (Darnerud et al. 2001; de Wit 2002; Rahman et al. 2001). Polybrominated diphenyl ethers (PBDEs), a subgroup of BFRs, were produced at a worldwide annual rate of 40,000 metric tons in 1999 (Rahman et al. 2001). There are three technical products of PBDEs, each with a different range of bromine substitution (Darnerud et al. 2001). These molecules are similar in structure to polychlorinated biphenyls (PCBs) and are specified using the same numbering scheme (Ballschmitter and Zell 1980). Their structural similarity to PCBs, known to have neurotoxic and carcinogenic action, begs the question of potential biologic hazards associated with PBDEs.

With the advent of governmental regulations banning their use, the levels of PCBs have been slowly decreasing in our environment (Dallaire et al. 2002); on the other hand, the levels of PBDEs are rapidly increasing (Noren and Meironyte 2000). PBDEs have been found in fish from the Great Lakes and rivers in the United States (Dodder et al. 2002; Hale et al. 2001; Luross et al. 2002; Manchester-Neesvig et al. 2001). PBDEs have also been reported in chickens, seafood, seals, and other aquatic mammals and in human milk, fat, liver, and serum samples (Booij et al. 2002; Christensen et al. 2002; Darnerud et al. 2001; Huwe et al. 2002; Jakobsson et al. 2002; Ohta et al. 2002; She et al. 2002; Sjodin et al. 2001). Examination of Swedish human milk samples from 1972 to 1997 showed an alarming, exponential increase in PBDE levels, with a doubling rate of about 5 years (Noren and Meironyte 2000). Similarly, blood concentrations in pooled samples from Norway show a 9-fold increase in PBDEs between 1977 and 1999 (Thomsen et al. 2002). Given these findings, the Swedish government voted to ban some lower brominated formulations of PBDEs by July 2003 (Betts 2002). It has recently been reported that PBDE levels in milk samples from Swedish women have decreased since 1997 (Hooper and She 2002); whether this trend is due to the voluntary phase-out of penta-PBDE is not certain. Concentrations in North America also appear to be increasing. Levels of congeners found in the penta-PBDE formulation have been increasing in ringed seal from the Canadian Arctic (Ikonomou et al. 2002) and herring gull eggs from the Great Lakes (Norstrom et al. 2002) since 1981.

Human exposure to PBDEs comes mainly from ingestion of dietary products, such as fish and cow's milk (Darnerud et al. 2001). Airborne contamination has also been implicated, particularly in the electronics and computer industries (Jakobsson et al. 2002; Sjodin et al. 1999).

The aim of our study was to determine the human fetal and maternal serum concentrations of PBDEs in central Indiana. Although based on only a small sample set, our findings indicate that women in Indiana are exposed to levels even higher than those that warranted banning the use of PBDEs in products sold in Sweden. This preliminary report indicates that further, large-scale studies will be needed to assess exposure levels across a broader population, to identify the sources of exposure in the United States, and to examine possible neurodevelopment deficits associated with high levels of exposure during fetal development.

Materials and Methods

Clinical materials. Institutional review board approval was obtained for studies involving humans. Patients who were older than 18 years, presenting in labor to Indiana University and Wishard Memorial County hospitals in Indianapolis during August–December 2001, were asked to participate. Pregnancies were full term, and no other major medical problems were noted in the mothers. Patients were asked to fill out a survey to determine age, race, smoking habits, potential occupational exposures to PBDEs (e.g., working in computer or electronics manufacturing, repair, or dismantling plants), and any other chemical exposures. Body mass index (BMI; kg/m^2) was calculated from the mother's height, prepregnancy weight, and weight at the time of delivery. Maternal blood was obtained when the patient was admitted to the labor and delivery suite, and fetal blood was obtained from the umbilical cord vein by syringe after delivery. The weight and presence of any congenital defects were noted for each baby.

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